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The Philippine Agriculturist

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The Philippine Agriculturist

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HERE AND THERE AMONG AGRICULTURAL COLLEGES IN EUROPE

On my way home from my last period of study in America (1920-23) I spent some weeks in a number of countries in Europe with the purpose of study, travel, recreation, and to satisfy a curiosity as to how they did things there compared with the way we do things in the Philippines and in America.

Being engaged in educational work in the Philippines I was naturally interested in educational institutions, especially agricultural schools, and in these, more specifically in the animal husbandry work. Naturally, then, the observations that follow were made from a rather biased point of view. Having no mission to fulfill nor directions to bind me, I just followed my natural inclinations. The order I will follow in this description is chronological in the sense that I will take the countries in the order in which I visited them.

GERMANY

The agricultural colleges in Germany go under the name of *Landwirtschaftliche Hochschule*. Usually they exist as independent units, but sometimes they form a college in a university. There are seven of these colleges, all government institutions. There are innumerable elementary agricultural schools scattered over the country. The name *Hochschule*, or high school may be misleading to us who have a different conception of a high school. The German agricultural high schools are on the same level in academic standing as the other branches of the university—as liberal arts, law, and medicine, for example. Compared with the American agricultural colleges or ours, the college standing is a little higher, in the sense that the students on entering are already prepared to take technical work. Students entering the university must first graduate from the *Gymnasium*, which is the nearest equivalent of our high school. The *Gymnasium* goes a little farther than our high school, so that when the students are graduated they have had a number of the equivalents of subjects that are usually taught in the first and second years of an American college; for example, languages, both German and foreign, history and mathematics.

If the University of Halle, with which I am better acquainted than with any other in Germany, is taken as typical, the requirements for a diploma in agriculture are the completion of prescribed subjects in seven departments, usually one or two in each department, requiring in general six semesters of resident study. The students have considerable freedom in the selection of the departments where they wish to take work. The usual departments represented in the *Landwirtschaftliche Hochschule* are: agronomy, animal husbandry, agri-

cultural chemistry, bacteriology, rural economics, veterinary science, anatomy and physiology, plant pathology, geology, botany, zoology, etc. Two more semesters of work, during which time the student writes his final dissertation in his chosen department prepares him for the degree of Doctor of Philosophy. The German doctorate is both a first and a last degree and is conferred in practically all branches of human knowledge. The *diploma* may be considered as equivalent to the Bachelor degree in the Philippines, although it is not considered as a degree in Germany. There is no equivalent to the Master's degree. In all sincerity, however, and knowing the grade of work turned out in both cases, the Master's degree as granted in this College, *on an average*, is the closest equivalent to the German Doctor of Philosophy that I know—our degree not suffering in the comparison.

From the point of view of a Filipino student, German University life appears very lax. After matriculating, the student is pretty free to do as he pleases. There are no roll calls, hardly any quizzes and no periodic examinations. Before receiving credit in a specific subject, however, he must satisfy the professor as to his knowledge of the subject through a special examination or written report or *arbeit* on some designated topic. While there are some students who waste their first one or two semesters in the University, drunk with the new privileges unknown in the closely supervised *Gymnasium* whence they have just come, the average German student is a steady worker and a regular attendant in his classes. The German student laughs at the American methods of pounding knowledge into unwilling students—roll calls, demerits, quizzes, examinations, reports to parents, etc. He laughs with reason as they are superfluous in his case.

Owing mainly to the fact that students take care of themselves, the German professor is able to do considerable work in the way of teaching, research, and administration. Most German university departments have only the professor and his assistant as technical personnel. The huge departments in American universities, where one finds as many as five or more professors, are practically unknown or very infrequently encountered in Germany. This, of course, is due to a great extent to the fact that there are comparatively many more schools for the population and the units are not large.

As to the method of instruction in the German *Landwirtschaftliche Hochschule*, it is very theoretical. In animal husbandry, for example, judging consists in the instructor pointing out the strong points and defects of the specimen on hand—demonstration in reality. The judging pavilion, so conspicuous in the American college, is not known in Germany. I visited the three most famous departments of Animal Husbandry (*Tierzuchtinstitut*) in Germany, and found that only one of them had any animals at all. The one in Halle, nationally considered as far above the others, had a collection of rare specimens of domestic animals, such as Przewalski horses, Zebus (Indian Cattle), Karakul and African fat-tail sheep, Arabian horses, etc., which are kept really as the name given to the collection, *Haustiergarten*, or garden of domestic animals, implies as animals in a "Zoo" rather than as farm animals.

A considerable proportion of the courses given are exclusively lectures, many of them subjects in which considerable laboratory work is given in the United States. The German professor of animal husbandry makes a brave effort to reduce his field of work to an exact science. As experimentation with farm

animals is necessarily of long duration and expensive, his progress gauged by actual accomplishment has been somewhat slower than that of his brother in England or America who has trusted more to his intuition, artistic, and practical sense, than to well-controlled experimentation to attain his ends. What is lacking in equipment as to living animals is supplemented by models and charts. In this respect the equipment in German universities is superior to that of American Colleges.

BELGIUM

There is only one agricultural school of collegiate grade in Belgium. This is the *Institut Agronomique de l'Etat* and is located in the small city of Gembloux, about forty miles southeast of Brussels. The requirements for admission is the completion of the *Bachelier* course as given in the preparatory school, or *Lycée*. This is almost the exact equivalent of the *Bachiller en Artes* as formerly given by the Spanish *Colegios* in Manila.

Two courses are given: One of two years duration leading to a diploma of *Licencie en Sciences Agronomiques*, and a four-year course leading to the degree of *Ingénieur*, in some agricultural specialty. The subjects taught in the first course allow no choice. They are experimental physics and meteorology, general and analytical chemistry, geology, zoology and entomology, botany and plant pathology, general and specialized agriculture, general and specialized animal husbandry, rural engineering, accounting, agricultural technology, and law. In the second course the first two years are similar to the first course, but there is a separate curriculum for the last two years according to the specialty chosen. The degrees conferred are: Agricultural Engineer of Colonial Agriculture, Engineer of Waters and Forests, Horticultural Engineer, Rural Engineer, and Engineer of Agricultural Industries. The various curricula are very similar but differ in the emphasis laid on the subject in which the degree is given.

This particular school has herds of cattle, horses, hogs, and some chickens, experimental gardens, orchards, and an instructional and demonstrational farm. The quality of instruction given is more practical than that given in the German universities.

FRANCE

The *Institut Agronomique* at Paris is the highest agricultural school in France. There are three national schools of agriculture, one at Rennes, one at Grignon, and one at Montpelier, which are almost of the same grade as the one at Paris. The *Institut Agronomique* gives a two-year course, mostly theoretical, in general agricultural physics, chemistry, zoology, botany, plant pathology, rural engineering, animal husbandry, etc. The preparation required is equivalent, approximately, to two years beyond the French *Bachelier*, and grants the degree of *Ingenieur Agronome*. The three institutions of subordinate grade require the *Bachelier*, alone, for preparation and grant the degree of *Ingenieur Agricole*. The first institution maintains a high standard through limiting its attendance to two hundred students; applications number over double this figure.

There is also at Nogent Sur Marne an *Institut National d'agronomie Coloniale*, which is really a post-graduate school giving a one-year course to graduates of any of the schools named above, as preparation for colonial service. It confers the degree of *Ingenieur d'Agronomie Coloniale*.

Being crowded in the middle of the city of Paris, the *Institut Agronomique* has little practical work outside that conducted in the laboratories. Instruction is supplemented by trips to farms, stockyards, and the abbatoirs.

GREAT BRITAIN

There are at least seventeen schools in England giving instruction in agriculture; about half of them are of collegiate standing. Contrary to expectation agricultural instruction is as yet not well developed in England. This is because it is almost wholly in the hands of private enterprises. Of late years the government, through the Ministry of Agriculture, has made contributions towards the support of certain projects in agricultural schools already established, and has granted scholarships tenable at these institutions. The schools of best repute are the School of Agriculture of the University of Cambridge, and the School of Agriculture of University College at Reading.

The main course in both these institutions is the degree course in agriculture granting a Bachelor's degree in Arts at Cambridge and in Science at Reading. This course is from three to four years duration. The students mark their progress by passing the yearly examinations. The subjects taught include history of agriculture and forestry, agriculture and mensuration, forestry, physics, chemistry, geology, botany, zoology, engineering, veterinary science, economics and accounting, plant pathology, and agricultural law. Students begin to specialize in the second year and this may be in agriculture, estate management, forestry, or horticulture.

The examination in the English schools is used for a purpose quite different from that in American schools. In American schools examinations are given to find out how much the student has learned in a course, while in England the examinations serve as standards for which students prepare themselves, in the same way as the Supreme Court examinations for lawyers in the Philippines, or the different Board examinations for licensing physicians, pharmacists, dentists, veterinarians, etc.

There is also a diploma course in agriculture of two years duration offered at Reading which requires at least one year farm practice as a prerequisite. This is intended especially for prospective farm managers to give them a scientific background for their practical knowledge. They take courses in agriculture, chemistry, botany, zoology, bookkeeping, entomology and veterinary hygiene.

The diploma course as given by Cambridge is totally different from that given at Reading. It is a post-graduate course of one or two years for students wishing to specialize further in practical agriculture, or in some branch of agricultural science.

There is a subject offered in English agricultural schools no longer encountered in American colleges; this is agriculture. The obsolete title of Professor of Agriculture in America is still commonplace in England. In his more general field this professor teaches everything under the sun that has anything to do with agriculture, from plowing to the construction of farm buildings, and from bookkeeping to the treatment of animal diseases. In his more restricted field he takes charge of the major work on the farm, including crop farming, livestock and dairying, and farm management. Great Britain, the country that has produced about ninety per cent of our improved breeds of stock, has no professors

of Animal Husbandry, and the famous British judges of livestock did not learn to judge in school as judging is not taught in their agricultural colleges. The facts of the case are that the different breeds were developed by born stockmen long before agricultural colleges were even dreamed of. So the livestock industry of Great Britain developed rather independently of agricultural educational institutions. This state of affairs is quite at variance with that found in America where the development of livestock industries in many regions is directly traceable to the agricultural colleges.

HOLLAND

The national Agricultural College in Holland is located at Wageningen and is known simply as *Landbouwschool*. The course is of four years duration with an additional year of farm practice required between the third and fourth years. The degree of *Ingenieur* either in Agriculture, Forestry, or Dairying is conferred. I expected to find this school following the German system, but it is more like the French and Belgian schools. The college maintains herds. The excellent dairy herd and the cheese factory are illustrative of the work they emphasize in animal husbandry. The school also maintains the usual departments of agronomy, chemistry, botany, physics, etc.

GENERAL OBSERVATIONS

While getting acquainted in general with the institutions visited, I made special inquiries regarding three points:

1. What is the extent of the practical work given to agricultural students?
2. What scientific work is accomplished by students?
3. What is the usual life work of the graduates?

In commenting on the answers to these questions I shall compare the European institutions with American agricultural colleges as well as with our own College in order that an idea may be gained as to how we stand among our sister colleges.

1. It is well known that agricultural colleges in America require farm experience from their students, but practically give none in their courses. The different colleges visited in Europe require farm experience in varying amounts. Holland probably holds most rigidly to such requirements and Germany the least. The closest to practical work that I saw students engaged in in the colleges themselves, outside the laboratories, was to follow a professor around the instructional farm, listen to him as he pointed out the object of the different cultures and work going on on the farm, record observations, and otherwise study the workings and the system of management of the farm. I did not see students engaged in actual manual labor outside. This system is quite different from ours, where we do not require farm experience outside but try to give it to the students in the college.

2. I found that practically no scientific work is accomplished by undergraduate students. Everywhere they are just passive "absorbers" of information dealt out by the instructional force. Essays are often required in connection with the subject taught, but there is no attempt at originality in these papers outside of the presentation. While there may be an occasional college in America that requires a thesis from its students, I found none among the European colleges visited. This is one phase of work highly emphasized in our college.

3. A large majority of the graduates in the different agricultural colleges go into educational, investigational, or administrative work of some kind, usually carried on under the auspices of the government, such as teachers, livestock inspectors, county agents, officials in experimental farms, etc. In England, France, Belgium, and Holland a considerable number are sent to the agricultural development projects in their colonies. The richer graduates go back home to manage the family farm holdings. A number start modestly in enterprises of their own, or secure positions as assistant farm managers, or as technical employees where there are agricultural industries. In this respect I did not find the future of our graduates any different from those of the countries visited.

B. M. Gonzalez
Of the Department of Animal Husbandry

RATE OF DECOMPOSITION OF ORGANIC NITROGEN IN RICE PADDY SOILS[1]

By Elias H. Panganiban

The rate of decomposition of organic nitrogen in Philippine rice paddy soils under field conditions is a subject which has not been investigated as yet. The organic materials in the soils, through the activities of certain bacteria, are decomposed with the consequent production of carbon dioxide, ammonia, amino acids, and nitrates. In studies made of the rate of decomposition of organic nitrogen occurring in nature, two methods are frequently employed. One method consists in the measurement of the rate of carbon dioxide evolution at definite intervals; the other, in the determination of the rate of formation of ammonia or nitrate nitrogen. The conditions in rice paddy soils during a great part of the year is such as to inhibit nitrate nitrogen formation completely, for it was observed (1) that when the soil is submerged in water, nitrates are found only in traces or are entirely absent. This is due to the lack of proper aeration, a condition which is necessary to the process of nitrification. Of course during the time when the soils are not submerged, nitrates accumulate, but when the land is flooded such nitrates are subsequently lost in the form of free nitrogen as a result of the action of certain anaerobic organisms. Evidently, it is out of the question to correlate the rate of decomposition of organic matter with the rate of production of nitrate nitrogen in rice paddy soils.

On the other hand, ammonification experiments with soils (1) have been carried out with dried blood as the source of nitrogen. Using varying amounts of water, starting from the air-dry soil and increasing the amount of water up to and beyond the saturation point, it was found that active ammonification took place even in completely saturated soil, which condition is approximately similar to that in submerged rice fields. Very little study of ammonia formation in rice paddy soils has been made. So far as the writer knows, investigation has been made only in Hawaii (1) where rice is generally grown in paddies. Analysis of the rice soils taken from the field when wet had shown that they contained considerable amount of ammonia, varying from a few parts up to as much as 50 to 60 parts per million. This presence of ammonia suggests the possible correlation of its formation in rice paddy soils and the rate of decomposition of organic nitrogen.

No work has yet been done which would correlate the production of amino acids with organic nitrogen decomposition, and yet amino acids are degradation products of proteins in which form most of the nitrogen in the soil organic matter is found. Chardet (2), who used Sorensen's method found from 49 to 68 per cent of the soil nitrogen to be amino acid nitrogen. Using Kober's method, Potter and Snyder (2) found only 7.95, 23.10 and 23.10 parts per million of the soil, which figures, if expressed in percentage of total nitrogen in the soil, correspond

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[1] Thesis presented for graduation with the degree of Master of Science from the College of Agriculture, No. 149; Experiment Station contribution, No. 119.

to 0.53, 1.25 and 1.10 per cent, respectively. They claim, moreover, that by Sorensen's method no nitrogen in the amino form could be found.

There is no available work yet published of a field study of carbon dioxide evolution in rice paddy soils. In 1906, Stocklasa and his collaborators (3), working under laboratory conditions, concluded from their results that the carbon dioxide evolution from the soil was inhibited by anaerobic conditions. Fraps (4) in 1915, however, showed that there is active evolution of carbon dioxide even when the soil is saturated with water.

The purpose of this work was to study the rate of carbon dioxide evolution in rice paddy soils simultaneously with the determination of their total nitrogen, ammonia, and amino acid contents before and during the period of growth of rice.

EXPERIMENTAL

PLAN OF THE WORK

Plans were laid out to analyze the soils for carbon dioxide ammonia and amino acids under the following conditions:

1. When the paddies were lying fallow.
2. When the paddies had been plowed and were ready to be planted.
3. After the paddies were planted and were either dry or submerged.
4. When the rice crop was mature with the paddies still submerged.

The total nitrogen, and in some cases the nitrate nitrogen, was also determined.

PADDIES USED

Paddies A.—These are paddies covering about 2,400 square meters of ground, behind the Administration Building of the College of Agriculture. These paddies were made in 1915. Since that year they had been planted to rice during the wet seasons and allowed to lie fallow during the dry seasons. No nitrogenous commercial fertilizers had been applied to these paddies so that the nitrogen in the soil came mostly from the vegetable matter of the soil. The condition in all rice paddies in the Philippines is similar to these in respect to the origin of nitrogen.

Paddies B.—These paddies are behind the new Chemistry Building of the College, and occupy about 6,400 square meters of ground. They are about 40 meters from the building. They were made in 1917, and since then had been planted to rice during the wet seasons and to either legumes or corn during the dry seasons. During the dry season of 1920, the paddies were planted to corn; and after harvesting the ears the rest of the plants were allowed to decay in the paddies thus enriching the soil organic matter. This rotation of corn or legumes with rice is practiced in many rice sections in the Islands, though on a very small scale, so that the condition in respect to organic matter of these paddies is similar to those in many localities.

SAMPLING

The soil samples were taken from the different parts of the paddies at a depth of fifteen centimeters by means of a trowel previously sterilized in a flame. The samples obtained were placed in an empty kerosene can sterilized with formaldehyde a day or two before the sampling. From ten to fifteen samples were obtained from the paddies and these were mixed as thoroughly as possible in the laboratory with the same sterilized trowel. After mixing the soil, the moisture

content was determined at once and samples containing a definite weight of the soil were taken for the different determinations.

METHODS OF ANALYSIS

Carbon Dioxide.—For the determination of carbon dioxide, the writer used Fred and Hart's method and apparatus (5) with slight modifications. The apparatus set up for this experiment consisted of a suction flask of about a liter capacity connected to a long glass cylinder with a 50 cc. pipette. The glass cylinder was two-thirds full of glass beads and held the 10 cc. normal sodium hydroxide. The beads were used to give a greater surface and to prevent the carbon dioxide from passing too rapidly through the alkaline solution.

After the amount of moisture present in the soil was determined, the equivalent of 500 grams of dry soil was placed in the flask and incubated at room temperature. To drive the carbon dioxide into the sodium hydroxide solution, a current of air freed from carbon dioxide by passing it through soda lime was passed through the apparatus for 10 minutes every day. The carbon dioxide was determined for 6 days, at two-day intervals, by titrating the alkaline solution, using the double indicator method for carbon dioxide (6), with standard sulphuric acid solution, each cc. of which was equivalent to 2 milligrams of carbon dioxide. This acid solution was slightly weaker than the N/10 used by Fred and Hart, and was very convenient for it simplified the calculations of the results. The results were expressed in milligrams of CO_2 per 100 grams of soil.

Ammonia.—Ammonia was determined by aeration following the method devised by Potter and Snyder (7). The equivalent of twenty-five grams of the moisture-free soil was placed in a 500 cc. Kjeldahl flask and 50 cc. of ammonia-free water and a few drops of heavy oil to prevent foaming were added. Then the rubber stopper bearing the tubes for the entrance and exit of the air was put in place. An absorption bottle of about 500 cc. capacity was filled with a mixture of 200 cc. of ammonia-free water and 5 cc. of N/14 sulphuric acid. This solution was about twice as strong as that used by Potter and Snyder (7). The Kjeldahl flask was then connected with the absorption bottle, after seeing to it that there was no water adhering between the rubber stopper and the mouth of the flask to collect ammonia. As many as eight or ten determinations were run in one series. The air, before entering the apparatus, was freed from ammonia by passing through a wash-bottle containing dilute sulphuric acid. Before the pump was started all the rubber stoppers bearing the tubes for entrance and exit of the air were loosened from the flasks, about two grams of sodium carbonate were added to the first flask closest to the pump, the flask shaken and then the rubber stopper inserted. The other flasks were treated similarly. After 20 hours of continuous aeration, and while the pump was still on, the flasks were disconnected one after another, starting with the one farthest from the pump. Then the contents of the absorption bottles were titrated with N/14 standard alkali using alizarine sulfonate as indicator. The results were expressed in parts per million of soil.

Amino Acids.—The writer followed Potter and Snyder's method (2) of extracting amino acids and the copper and Kober's method (8) for the determination.[2] This method was used also by Potter and Snyder, with some modifica-

2 This method will include the amino acids found in the cells of the soil micro-organisms.

tions. Enough sample to give 150 grams of dry soil was weighed and placed in a bottle; 300 cc. of 4 per cent sodium hydroxide and enough water to give 600 cc. of 2 per cent alkali were then added. After shaking for two hours, the dark colored extract was filtered over night, instead of whizzing it in a centrifuge as recommended by Potter and Snyder (2). Eighty cc. of this solution was transferred to a 100 cc. flask and made almost neutral with 1-1 hydrochloric acid solution; 7 cc. of a saturated solution of lead acetate, 7 cc. of ammonium hydroxide (sp. gr. 0.90) to precipitate the excess of lead, and enough water to complete the volume to 100 cc. were added. The mixture was shaken thoroughly and then filtered. To 75 cc. of the filtrate, 25 cc. of saturated barium hydroxide were added, and the ammonia removed by boiling at a pressure of about 25 mm. The liquid was then made up to 75 cc., the barium carbonate precipitate filtered and 50 cc. of the clear solution placed in a 100 cc. flask. The solution was then made barely alkaline to phenolphthalein by the addition of concentrated hydrochloric acid, 40 cc. of the "buffer" solution added, and after cooling for two hours or more in an ice box, 1 cc. of the cooled suspension of freshly prepared cupric hydroxide in water was then pipetted in, made up to the mark with water and the whole was shaken, and finally filtered through Whatman Genuine filter paper No. 42. Fifty cc. of the filtrate were placed in a beaker, slightly acidified with 5 per cent nitric acid, heated to boiling, and bromine water added till a permanent color was given. The solution was then boiled down to about 10 cc. and in order to be sure that the last trace of bromine was expelled, 35 cc. of water was added and boiled down again to 10 cc. The solution was cooled, made slightly alkaline with sodium carbonate and made acid with glacial acetic acid. After the addition of potassium iodide and starch solution, the free iodine liberated by copper was titrated with sodium thiosulphate the normality of which was 0.001. Each cc. of this solution was equivalent to 0.0280 mgs. of total amino acid nitrogen. The results were expressed in parts per million of soil.

Total Nitrogen.—The writer used the official method for the determination of the total nitrogen (9).

Nitrates.—The modified phenol-disulfonic-acid method (10) was used. Two samples, each weighing the equivalent of 50 grams of dry soil, were placed in the shaking bottles, 5 grams of calcium carbonate and water were added. The amount of water added was such as to make the total weight of water including that already present exactly 200 grams. The bottles were shaken vigorously for one minute, three times, at half-hour intervals. The soil extracts were then passed through the filter and treated as follows: Five cc. of the filtrate were placed in porcelain dishes and evaporated to dryness on the water bath. When the dishes were cooled, 1 cc. of the phenol-disulfonic-acid solution was slowly poured around the dishes and allowed to spread over and soak the dry residue; the dishes were rotated so as to make sure that the acids came in contact with the nitrates. The dishes were then allowed to stand for 15 minutes, and then treated with about 15 cc. of cold distilled water. By means of a wash bottle, the solutions were made alkaline with dilute ammonium hydroxide (4 to 8 per cent) until the yellow color was permanent. The standard nitrate solution was treated in the same way. The unknown nitrate solution was then compared with the standard in a Schreiner colorimeter.

PRELIMINARY EXPERIMENTS

Before the series of experiments were conducted, according to the plan, trial experiments were run. The first of these was on the determination of ammonia nitrogen. Potter and Snyder (7) in their experiments used about 250 liters of air an hour for twenty hours. The only available pump in the laboratory permitted only about 100 liters of air an hour; so that tests were made to lengthen the time of aeration. Experiments using 20 hours, 27 hours and 44 hours of aeration were conducted, using samples of soils from the paddies behind the new Chemistry Building. The results are shown in Table I. The soil was taken December 2, 1919. when the paddies contained maturing rice and the ground was not submerged in water. The soil contained 26.43 per cent of moisture.

TABLE I.—*The results of the different time of aeration.*

Time of aeration.	Samples.	Mgs of NH_3–N in 25 gms. soil.	Parts per million.	Average p.p.m.
20 hours	1	1.18	47.2	
	2	1.48	59.2	
	3	1.04	41.6	
	4	1.11	44.4	43.1
27 hours	1	0.81	32.4	
	2	0.81	32.4	
	3	0.89	35.6	
	4	0.89	35.6	34.0
44 hours	1	1.25	50.0	
	2	0.89	33.6	
	3	1.04	41.6	
	4	0.67	26.8	35.5

By comparing the results of 20 hours, 27 hours and 44 hours, it may be seen that the highest amount of ammonia nitrogen was obtained in the 20-hour aeration. The 27 and 44 gave too low results.

These lower results may have been due either to sampling or to a possible dissociation of ammonium sulphate formed in the receiving bottles during the longer aeration and a consequent loss of ammonia.

To obtain light on the second supposition, the following experiment was conducted:

Aliquots of the standard sulphuric acid with ammonia equivalent to that found in the trial experiment after 20 hours of aeration were placed in the receiving bottles with the usual quantity of ammonia-free water. Three of these preparations were aerated for 7 hours and three for 24 hours. Three others were used as blanks. The results are found in Table II.

TABLE II.—*Number of cubic centimeters of alkali used in titration.*

Aeration.	c. c. alkali.		
	I.	II.	III.
Blank	4.23	4.25	4.20
Aerated for 7 hours	4.20	4.22	4.26
Aerated for 24 hours	4.15	4.22	4.20

Table II shows that the longer aeration did not cause any loss of ammonia, thus showing that the lower results obtained in Table I for the 27-and 44-hour aeration were probably due to poor sampling or to some other cause. Since no single determination in the 27-and 44-hour aeration gave higher results than the 20-hour, the latter was considered sufficient and was used in the following experiments.

The second trial experiment was on the determination of carbon dioxide evolution. The soil was from the paddies behind the new Chemistry Building, taken on February 17, 1920, after heavy rains and contained 24.33 per cent of moisture. The paddies had just been plowed after lying fallow. The results are presented in Table III. The total nitrogen of this soil was also determined and found to be 0.120 per cent.

TABLE III.—*Carbon dioxide evolved during 12 days.*

Two-day periods.	Mgs. carbon dioxide in 100 gms. soil.		
	I.	II.	III.
February 19, 1920.....	Lost	Lost	Lost
February 21, 1920.....	15.14	14.39	15.98
February 23, 1920.....	6.95	6.98	10.06
February 25, 1920.....	3.06	3.25	4.32
February 27, 1920.....	2.94	2.94	2.83
February 29, 1920.....	3.64	3.48	2.71
Total.....	31.73	31.04	35.90

It will be seen from Table III that the carbon dioxide evolution decreased rapidly after the sixth day, which result coincides with Frap's in his work (4) on the decomposition of cotton seed. The table gives concordant results.

EXPERIMENTAL RESULTS

PADDIES A

First Set.—Samples were taken April 20, 1920, while the paddies were lying fallow. The soil contained 20.22 per cent of moisture and 0.091 per cent of total nitrogen.

Second Set.—Samples were taken May 10, 1920, after two days of heavy rain and while the paddies were still lying fallow. The soil contained 31.95 per cent of moisture and 0.100 per cent of total nitrogen.

Third Set.—Samples were taken November 9, 1920, while the paddies were submerged and planted with rice. The soil contained 0.184 per cent of total nitrogen but no nitrate nitrogen.

Fourth Set.—Samples were taken December 12, 1920, while the paddies were submerged and growing maturing rice. The soil contained 0.219 per cent of total nitrogen but no nitrate nitrogen.

PADDIES B

First Set.—Samples were taken July 17, 1920, after several rainy days. The soil had been plowed and was ready for planting. It contained 24.77 per cent of moisture and 0.110 per cent of total nitrogen.

Second Set.—Samples were taken August 12, 1920. The paddies were growing rice, about two weeks old. The soil was drying and beginning to crack in places. It contained 17.80 per cent of moisture and 0.125 per cent of total nitrogen.

Third Set.—Samples were taken November 25, 1920, while the paddies were submerged and growing maturing rice. The soil contained 0.195 per cent of total nitrogen but no nitrate nitrogen.

Fourth Set.—Samples were taken December 29, 1920, while the paddies were submerged and growing maturing rice. The total nitrogen found was 0.209 per cent. It had no nitrate nitrogen.

(Table IV records the carbon dioxide evolved in 12 days in Paddies A and B.)[3]

DISCUSSION OF RESULTS

Taking the results in Paddies A for every individual set of analyses, it will be seen that during the dry season when the fields were lying fallow the carbon dioxide evolution from the soil, kept under laboratory conditions, was rather slow, while its ammonia content was relatively high, ranging from 58.0 to 77.6 parts per million. Its amino acid nitrogen averaged 8.82 parts per million. This was 0.969 per cent of total nitrogen in the soil. This result is within the range found by Potter and Snyder (2) for upland soils which was from 0.53 to 1.25 per cent of the total nitrogen.

The second set of analyses, where the sample was taken after two days of heavy rain and the soil contained 31.95 per cent of moisture, showed high rate of carbon dioxide evolution but low ammonia content. The amino acid nitrogen was found to be slightly lower, and the total nitrogen slightly higher than in the first set. This higher rate in the carbon dioxide evolution agrees with the results obtained by Lewis and Cunningham (3) in India, who found that the carbon dioxide in the soil studied increased after a rainfall. The low result for ammonia, on the other hand, was probably due to a more active nitrification of the soil because of the more favorable condition. Active rate of nitrification in Philippine soils (11) was observed when the soils contained a high percentage of moisture. The slight decrease in the amount of amino acids can be attributed to more active ammonification.

A comparison of the results from the first two sets of analyses seem to show that the rate of decomposition of organic nitrogen in the soils cannot be measured by ammonia or amino acid formation, alone. The first set showed a slow carbon dioxide evolution which amounted only to 15.69 milligrams per hundred grams of soil for a twelve-day period; while there was a large accumulation of ammonia, a fact which may have been due to very slow nitrification. In the second set, however, the reverse was true. There was a high rate of carbon dioxide evolution, but apparently slow ammonia and amino acid formation.

The third set of experiments with submerged soil, showed active carbon dioxide evolution, a result which was similar to that obtained by Fraps (4) with soils of very high moisture content. This set gave a decreased amount of ammonia, a slight increase in amino acid nitrogen, and a marked increase in total nitrogen.

The fourth set showed the same rate of carbon dioxide evolution as Set 3, but much less ammonia, and a greater amino acid and total nitrogen content.

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[3] Four tables, one showing total nitrogen found in Paddies A and B in the four sets of experiments; one showing ammonia nitrogen; one showing amino acid-nitrogen; and one showing nitrate-nitrogen are omitted owing to lack of space in **The Philippine Agriculturist**. These tables are on file in the Chemistry Department of College of Agriculture where they may be consulted or copies will be furnished on application.

In the first set of experiments in Paddies B, the carbon dioxide evolution and the amino acid and total nitrogen content did not show any noticeable differences from those for the corresponding periods of Paddies A. This indicates that the two paddies were similar in respect to their bio-chemical properties. The ammonia content, however, was only about one fourth of that found in the soil for the corresponding period in Paddies A when the soil was lying fallow. As previously stated, the samples were taken after several rainy days and after the paddies had been plowed and were ready for planting. In all probability, the ammonia formed during the rainy days was in great part transformed into nitrates, for nitrification was probably favored by higher moisture content and by better aeration brought about by plowing.

The second set of experiments showed a lower rate of carbon dioxide evolution, which coincided with a lower moisture content of the soil. It also showed less ammonia and amino acid nitrogen but more total nitrogen.

The third and fourth sets showed, as in Paddies A, more active carbon dioxide evolution when the soils were submerged. However, only traces of ammonia were found in Set 3, and 3.4 parts per million in Set 4, while the amount of amino acids and total nitrogen increased in both sets.

A summary of the results for both Paddies A and B is given in Table V. It may be observed that there seems to be a direct relation between the carbon dioxide evolution and the moisture content of the soil under aerobic condition, for a low percentage of moisture was accompanied by a low carbon dioxide evolution and a high percentage of moisture by a high carbon dioxide evolution. Brown (12) found that the decomposition of organic nitrogen in soil is largely accomplished by bacteria and that the number of bacteria in the soil decreased as the moisture decreased. If carbon dioxide evolution in soil is correlated with the bacterial activity then the results recorded in this paper are what might be expected. With respect to the differences in the nature of the nitrogenous matter in submerged soils as compared with those not submerged, it can be said that it may have been due to the differences in the bacterial flora. The bacteria acting on the organic matter in submerged soils were anaerobic, while those acting under the latter conditions were aerobic.

In both paddies, there was a decided increase in total nitrogen. The increase, however, was more appreciable when the paddies were submerged and when the rice was maturing or was already matured. Apparently the increase can be accounted for only through the process of nitrogen fixation. Greaves and Carter (13) showed that there is nitrogen fixation in both aerobic and anaerobic conditions. Fischer (15) (16) found that there was a good rate of nitrogen fixation in soils under water and considered that the significance of free living nitrogen-fixing bacteria, especially the aerobical and radiobacterial forms could be favorably compared with that of the nodule bacteria for the legumes. Further, he found that nitrogen fixing bacteria enriched tenfold the ground at the bottom of the pond, a condition practically similar to rice paddy soils under submerged conditions. This shows that there is an extraordinary nitrogen fixation in soils under water and Fischer explained that this excessive nitrogen fixation is due to (1) nitrogen fixation by lower fungi, (2) synthetic action of enzymes produced by the decomposition of protein compounds in the soils, (3) symbiosis between green water plants, especially algae and short bacilli of pneumonia group, and

(4) anaerobic bacteria. The above findings of Fischer may fully account for the findings reported in the present work. Why this fixation, if it took place in this particular soil, was more pronounced when the soil was submerged in water, may probably be explained by the reduced rate of ammonification and total absence of nitrification under anaerobic condition. Russell (14) states that the gain of nitrogen in the soil would not go on indefinitely. In course of time a point of equilibrium would be reached where further gains would be balanced by losses, so that the nitrogen content would remain constant; and thus there would be an upper limit as well as a lower limit to the nitrogen content, depending on the soil conditions, between which limits the nitrogen content might be maintained. Moreover, Russell said that direct plowing and cultivation operations as shown by the analyses of the Indian Head soil, caused a great loss of nitrogen and that only one third of the nitrogen lost was recovered by the crop. Thus a great part of the nitrogen accumulating in the rice paddies when submerged in water may be lost during the preparation of the soil for planting. Small losses would also be observed during aerobic conditions, for the decomposition of nitrogenous compounds under aerobic conditions may be accompanied by a loss of nitrogen (14).

Ammonia decreased in both Paddies A and B during submerged conditions. In the case of Paddies A, the ammonia found decreased from 66.70 parts per million when the soils were lying fallow to traces during the time when the soils were planted and submerged. This result agrees with those obtained by Kelley (1) who worked on rice paddy soils in Hawaii. In the discussion above, it is stated that there was active decomposition of organic nitrogen even under submerged conditions as indicated by active carbon dioxide evolution, and the fact that there was very little ammonia in submerged conditions in both paddies would naturally call for some explanation. What becomes of the ammonia nitrogen that would be formed during such decomposition? Quantitative test for nitrate nitrogen showed negative results. The partial or total absence of ammonia nitrogen in submerged soils can only be accounted for by the supposition that it was absorbed by rice as fast as it was formed and by the reduced rate of ammonification of the amino acids. Kelly (17) in Hawaii showed that lowland rice could assimilate nitrogen in the form of ammonia and that this form of nitrogen was rather preferred to nitrates by the rice plant.

In both Paddies A and B there was, however, a slight increase in the amino acid nitrogen content under submerged conditions although the percentage of this form of nitrogen in terms of total nitrogen was lower than under aerobic conditions, so that the increase of actual amino acids in the soil was not proportional to the increase of total nitrogen. A statement was made in the introduction to this paper that the amino acids were intermediate products of the decomposition of organic nitrogen. These amino acids are in turn de-aminized by organisms with the formation of ammonia. Kelley (1) showed that ammonification takes place even in soils under submerged condition although at a lower rate than under aerobic condition and with optimum moisture in the soil. The decrease of amino acid nitrogen in proportion to the total may be due either to reduced hydrolysis of the protein nitrogen or to direct assimilation of the amino acid nitrogen by the rice plant or to both. Potter and Snyder (2) pointed out that under certain conditions, amino acids may be utilized by the plants.

PRACTICAL APPLICATION OF THE EXPERIMENTAL RESULTS

It is known that the application of nitrogenous fertilizers in the form of ammonium salts to the soil increases rice production per unit area. In Hawaii, for example, investigators found that fertilization with ammonium salts produced a considerable increase in the yield of rice (1). Recent investigations (18) carried out at the College of Agriculture, University of the Philippines, showed that highest straw and highest grain yields were positively correlated with salt mixtures containing highest proportion of ammonium sulphate and lowest with those containing lowest proportions of the salt. The results of the present work show that there was very little nitrogen in the form of ammonia during the time the ground was submerged in water. There was of course accumulation of ammonia while the soils were lying fallow, but the accumulated ammonia was apparently rapidly converted into nitrates which were most likely denitrified as soon as the soils were flooded. These findings seem to show why the application of ammonium salts is favorable to rice.

The application of organic matter containing protein nitrogen to rice paddies, the usual practice in many localities, may prove beneficial under aerobic conditions, but not in submerged soils for its decomposition would be very slow, and would not produce enough ammonia nitrogen to supply the immediate need of the crop.

SUMMARY

1. During the dry season when the rice paddies were lying fallow, the decomposition of organic matter was slow as measured by carbon dioxide evolution, but there was a large accumulation of ammonia nitrogen.

2. There was an active evolution of carbon dioxide after heavy rains, and nitrification proceeded rapidly with the consequent conversion of ammonia nitrogen into nitrates.

3. The rate of decomposition of organic nitrogen can not be measured by the ammonia and amino acid content of the soil, for they may be transformed into other forms of nitrogen as fast as formed.

4. Carbon dioxide evolution was active even in submerged soils, but the ammonia present was much less than under aerobic condition.

5. The evolution of carbon dioxide under aerobic conditions was affected by the moisture content of the soils; the low percentage corresponded to low carbon dioxide evolution and the high percentage to high carbon dioxide evolution.

6. There was an appreciable increase of total nitrogen, presumably caused by nitrogen fixation.

7. The ammonia nitrogen content of the paddies was practically zero under submerged conditions probably due to a rather slow rate of decomposition and rapid absorption by rice.

8. Nitrates were absent in submerged soils.

9. There was a slight increase of amino acids in the soils under anaerobic conditions but this increase was not proportional to the increase in total nitrogen.

ACKNOWLEDGMENT

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TABLE IV.—*Showing carbon dioxide evolved during 12 days in Paddies A and B for the four sets of experiments.(Figures express milligrams of carbon dioxide per 100 grams of soil.)*

Paddies.	Set No.	Date.	Sample number. 1	2	3	Average.	Moisture.	Soil conditions.
		1920	*mg.*	*mg.*	*mg.*	*mg.*	*per cent*	
		April 22	3.65	4.11	4.00			
		April 24	3.09	2.92	3.08			
		April 26	2.15	2.50	2.38			
	1	April 28	1.71	1.94	1.77		20.22	Paddies lying fallow
		April 30	1.25	1.54	1.54			
		May 2	1.38	1.54	1.52			
		Total....	13.23	14.55	19.29	15.69		
		May 12	11.98	13.39	12.11			
		May 14	8.01	8.09	7.53			After two days of heavy rain and while the paddies were still lying fallow
		May 16	5.86	5.61	4.96			
	2	May 18	5.05	4.37	5.18		31.95	
		May 20	6.03	5.09	5.39			
		May 22	4.79	5.61	5.26			
A		Total....	41.72	42.16	40.43	41.44		
		Nov. 11	6.72	7.82	6.38			
		Nov. 13	4.93	4.03	4.15			
		Nov. 15	3.32	3.28	3.36			Paddies submerged and planted with rice
	3	Nov. 17	2.97	3.18	3.18		41.86	
		Nov. 19	3.49	4.05	3.45			
		Nov. 21	2.88	2.53	3.05			
		Total....	24.31	23.89	23.57	23.92		
		Dec. 14	6.57	6.79	6.97			
		Dec. 16	3.90	3.94	4.07			
		Dec. 18	4.18	2.85	3.38			Paddies submerged and rice maturing.
	4	Dec. 20	3.63	3.25	3.34		40.58	
		Dec. 22	3.21	2.74	2.78			
		Dec. 24	3.34	2.74	2.85			
		Total....	24.83	22.31	23.39	23.51		
		July 19	4.59	4.98	4.21			
		July 21	4.52	4.10	4.71			After several rainy days
		July 23	2.91	2.83	2.87			
	1	July 25	3.37	3.60	3.03		24.77	Soil had been plowed and was ready for planting
		July 27	2.64	2.76	2.57			
		July 29	2.49	1.69	1.81			
		Total....	20.52	19.96	19.20	19.89		
		August 14	4.47	6.84	5.10			
		August 16	2.96	2.82	2.82			Paddies contained rice about two weeks old. Soil drying and beginning to crack
		August 18	2.06	2.06	1.80			
	2	August 20	1.39	1.28	1.50		17.80	
		August 22	1.35	1.50	1.61			
		August 24	1.39	1.28	1.50			
B		Total....	13.62	15.78	14.33	14.58		
		Nov. 27	6.97	5.98	5.72			
		Nov. 29	3.99	3.72	3.19			
		Dec. 1	3.22	3.15	2.69			Paddies submerged and growing maturing rice
	3	Dec. 3	2.34	2.42	2.42		33.85	
		Dec. 5	2.49	2.42	2.53			
		Dec. 7	2.11	2.19	1.77			
		Total....	21.12	19.88	18.32	19.77		
		Dec. 31 1921	5.47	5.58	5.62			
		Jan. 2	2.83	3.95	3.33			Paddies submerged and growing matured rice
		Jan. 4	2.41	2.64	2.64			
	4	Jan. 6	2.09	2.22	1.78		34.33	
		Jan. 8	1.97	2.12	1.97			
		Jan. 10	1.97	1.97	1.89			
		Total....	14.74	18.48	17.23	16.82		

TABLE V.—*Summary table for Paddies A and B.*

Paddies	Set No	Soil conditions.	Date	Moisture.	CO_2 in 100 grams soil in 12 days. Average of three samples.	Total average of three samples.	NH_3 N Average of eight samples.	Amino acid N Average of two samples.	NO_3 N Average of two samples.	NH_3 N in terms of total N.	Amino acid N in terms of total N.
			1920	*per cent*	*mg.*	*per cent*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*per cent.*	*per cent.*
A	1	Paddies lying fallow	April 20	20.22	15.69	0.091	66.70	8.82	Not determined	7.329	0.969
	2	After two days of heavy rain and while the paddies were still lying fallow	May 10	31.95	41.44	0.100	26.25	8.39	Not determined	2.625	0.839
	3	Paddies submerged and planted with rice	Nov. 9	41.86	23.92	0.184	14.30	9.01	none	0.777	0.489
	4	Paddies submerged and rice maturing.	Dec. 12	40.58	23.51	0.219	trace	10.72	none	———	0.498
B	1	After several rainy days. Soil had been plowed and was ready for planting	July 17	24.77	19.89	0.110	17.50	8.51	Not determined	1.591	0.774
	2	Paddies growing rice about two weeks old. Soil drying and beginning to crack	Aug. 12	17.80	14.58	0.125	16.05	8.45	Not determined	1.284	0.677
	3	Paddies submerged and growing maturing rice	Nov. 25	33.85	19.77	0.195	trace	9.12	none	———	0.466
	4	Paddies submerged and growing matured rice	Dec. 29	34.33	16.82	0.209	3.40	9.45	none	0.166	0.462

INSECT CARRIERS OF *DIPLODIA* IN STORAGE-ROTS[1]

By Valeriano M. Sarmiento

INTRODUCTION

Dry rot caused by *Diplodia* is a common disease of stored agricultural crops. Its development is favored by improper storage conditions which allow access to certain agents of dissemination, coupled with the lack of care and undue handling of the material.

EXTENT OF DAMAGE RENDERED BY *Diplodia*

According to Reyes (1) this fungus and its allies are prevalent in this country and abroad attacking a great number of plants, including stored roots, seeds, and fruits. A fifty per cent loss of sweet potatoes in the College of Agriculture was estimated. It is reported that in the storage houses in the United States an annual loss in sweet potatoes amounts to several million dollars. Reyes (1) observed *Diplodia* sp. to cause great damage to *gabi* (taro), yautia, and yams; to roots of cassava; to stored mango, jackfruit, cacao, papaya, citron, and banana. It also infects egg-plant, soursop, squash, lima bean, cotton bolls and *ubi* (yam). A considerable loss of watermelons was observed in Washington, D. C. Harter[2] considers *Diplodia* to be the most destructive of all the storage-rots. Pole Evans[3] found it to affect all varieties of citrus in South Africa.

With an aim to reduce the great losses of stored products, or to make storing profitable, various studies have been made, but no end as yet has been attained owing to the wide scope of the problem involved. Fungi causing storage rots are numerous. They are disseminated by spores which are very small and light so that their spread is made easy through various agencies that come in contact with them. Several types of distribution have been found, such as pedestrians, pickers, or harvesters, animals, birds, insects, running water, wind, etc. Barrett and Burrill[4] demonstrated that spores of *Diplodia* could be blown by wind 350 yards from the infected ears of corn. Wolf (2) found that wind carries spores of *Cercospora personata* (B. & C.) C. He made no tests to determine how far they could be blown, but his exposures, eight feet from infected plants, showed their presence. Levin[5] showed that wind and water carry spores of *Septoria lycopersici* Speg. Martin (3) scraped the hands and garments of the tomato fruit-pickers to prove that they were carriers of *Septoria lycopersici* Speg., and *Alternaria solani* (E. &. M.) Jones and Grout.

The writer of this paper assumed that the insects found feeding or hibernating on stored crops attacked by *Diplodia* were carriers of the pathogene in some such way as are pedestrians, tomato-fruit pickers, or the insects that pollinate flowers with the pollen grains that adhere to their bodies.

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[1] Thesis presented for graduation from the College of Agriculture, No. 150; Experiment Station contribution, No. 120.

[2] *Cited* by Reyes (1).

[3] *Cited* by Reyes (1).

[4] *Cited* by Martin (3).

[5] *Cited* by Martin (3).

This work was designed, therefore, to determine (a) what insects carry *Diplodia*, if they do, (b) how transmission of the fungus is accomplished by them, and finally (c) control measures deduced from the study.

This work was undertaken during the school years 1920-21 and 1921-22 at the College of Agriculture, Los Baños.

REVIEW OF LITERATURE

There were no reports on the transmission of *Diplodia* by insects in storage-rots previous to 1920 when Reyes (1) found that weevils disseminated the disease, but he was unable to prove this positively. Investigators, however, have found that insects act as carriers of pathogenes from infected to healthy plants.

Stevens (4) mentioned insects as one of the probable carriers of citrus canker. Reinking (5) attributed the responsibility of spread of coconut bud-rot to insects that bore holes on the stem just opposite the bud. Butler (6) observed that epidemics of red rot and rind disease of sugar cane often follow severe attacks of cane flies. Because the acervuli break through the cuticle exposing numerous spores, with the presence of white flies, Tisdale (7) believed these insects to be the carriers of *Melanconium* spores on tomatoes. Experimenting with tomato leaf-spot, Martin (3) concluded that some insects belonging to the families Sphingidae, Chrysomelidae, and Coccinellidae are carriers of spores of *Septoria lycopersici* Speg., and *Alternaria solani* (E. & M.) Jones and Grout., in their digestive systems and on their bodies.

In 1913 Stewart (8) reported that the tarnished plant bug, and in 1915, (9) the insects feeding upon the exuding sap from wounds made by hailstones on pear trees, are carriers of the fire-blight organism, *Bacillus amylovorus* (Burr.) De Toni. According to Stewart and Leonard (10) the sucking insects which puncture apple and pear seedlings, rather than the flies that make no injury, and according to Burrill (11) the aphids *Aphis avenae* Fab., and *Aphis mali* De G., are carriers of the fire-blight and are effective in causing infection. Hesler and Whetzel (12) stated that wasps, bees, flies, bugs, beetles, aphids, curculios, and leaf hoppers may carry the bacterial pathogene to the opening blossoms, tender twigs, and wounds in the bark of pear trees. Burrill (13) reported that pomace-flies transmit the bitter rot of apples, *Glomerella rufomaculans* (Berk.) S. & S. Gloyer and Fulton (14) arrived at the conclusion that the tree crickets on apple trees are not only carriers of *Leptosphaeria coniothyrium* (Fckl.) Sacc., from raspberries to apple trees, but also carry spores of other fungi.

Smith and Boncquet (15) found that *Eutettix tenella* Baker had no effect upon sugar beets, unless it had sucked diseased leaves and retained the juice for 24-28 hours, after which it efficiently produced the curly leaf. Pool and McKay (16) mentioned insects as carriers of *Phoma betae* (Oud.) Fr., and (17) showed later by plating that *Diacrisia virginica* Fab., *Monoxia juncticollis* Say., and *Loxostege sticticalis* L. (the webworm) are carriers of *Cercospora beticola* Sacc.

Rand (18) believed that the cucumber beetle, *Diabrotica vittata* F., is chiefly responsible for the dissemination of the wilt of cucurbits. From water in which twelve spotted beetles were washed, Carsner (19) succeeded in plating the angular leaf spot of cucumber in potato-dextrose-agar. Rand and Cash (20) found that *Bacillus tracheiphilus* E. F. Sm., the cause of cucumber wilt, gained entrance through the punctures made by *Diabrotica vittata* F., and *Dia-*

brotica 12-punctata Oliv. The excrements of these insects are also capable of producing infection.

At Big Rapids, Michigan, Doolittle (21), 1915, showed that *Aphis gossypii* Gl., transmitted the mosaic disease of cucumber from infected to healthy vines. In the same year in the vicinity of New York, Jagger (22) made a similar observation.

The co-operative project carried by the Bureau of Plant Industry, U. S. Department of Agriculture, and the Department of Plant Pathology, Agricultural Experiment Station, Maine, as reported by Folsom (23) resulted in the conclusion that aphids, or plant lice, are important agents in the transmission of potato mosaic. Because the flea-beetle attacks potato leaves, the host of the blight organism, Jones and Vaugan (24) states that it disseminates the pathogene. Recently, Morse (25) found that both the flea-beetle, *Epitrix cucumeris* Harris, and the pink and green aphids, *Macrosiphum solanifolii* Ash., were responsible for the dissemination of late blight of potatoes.

Wolf (2) found that grasshoppers are agents in the distribution of *Cercospora personata* (B. & C.) C., he also stated that digestion did no harm to the vitality of the spores. Other spores were found on the insects' bodies, such as *Puccinia cassipis*, *Alternaria* sp., *Fusarium* sp. *Helminthosporium* sp., and *Ravenelia* sp.

Experimenting with mosaic disease of sugar cane, corn, and other grasses, Brandes (26) concluded that *Aphis maydis* Fitch., transmits corn mosaic.

Jagger (27) demonstrated that *Myzus persici* Sulz. disseminates lettuce mosaic.

Allard (28) reported that *Myzus persici* Sulz., and the plant louse, *Macrosiphum tabaci* are efficient carriers of the mosaic disease of tobacco.

Certain insects under the orders Hemiptera, Coleoptera, Diptera, and Hymenoptera, as determined by Studhalter (29) are carriers of chestnut blight. Craighead (30) believed that the spores of this disease, gained entrance through wounds caused by cicadas, aphids, tree crickets and tree hoppers.

Regarding the spinach blight, McClintock and Smith (31) reported that aphids have to remain on the plant at least fourteen hours before they can efficiently cause infection.

From a series of experiments, Gravatt and Marshall (32) concluded that snails, slugs, weevils, and sowbugs were carriers of uredospores and sporidia of *Cronartium ribicola* F. de Wal. These spores adhere to the insects' bodies at least a week under certain conditions. Numerous aeciospores and uredospores were found on the bodies of the gipsy-moth's larvae, and because the Bureau of Entomology found that these larvae are carried by wind 20 miles, Gravatt and Posey (33) concluded that the blister-rust of pine trees is disseminated by the larvae. After further observation and experimentation with insects collected from *Ribes* bushes, Snell (34) stated that every insect may at times become a carrier of spores of *Cronartium ribicola* F. de Wal.

After reviewing the literature on insect transmission of plant and animal diseases, Rand and Pierce (35) made this statement, "The final criterion, then, should be the actual transmission of the disease under controlled conditions simulating as nearly as possible those found in nature".

MATERIALS AND METHODS

The available root crops during the progress of the work were tubers of cassava, *gabi* (taro), sweet potato, and citrus fruits.

INSECTS

The insects found associated with the root crops attacked by *Diplodia* spp. are presented in Table I. These groups of insects were observed to be the most abundant. There were, however, several others not here considered. Table I gives the insects, families to which they belong, and the hosts where they were most frequently found.

TABLE I.—*Insects found on stored seeds, roots, and fruits.*

Insect.	Family.	Host.
Araeocerus fasciculatus De Geer	Anthribidæ	cassava, eggplant, sweet potato, *tuge*, *ubi*, (yams), citrus, and *gabi* (taro)
Cylas formicarius (?) Fab.	Curculionidæ	sweet potato
Calandra oryzæ Linn.	Calandridæ	beans, rice, corn, *gabi* (taro), cassava, sweet potato, *ubi*, and *tuge* (yams)
Dinothrips sumatrensis Bag.	Phlœothripidæ	cassava
Musca domestica Linn.	Muscidæ	Any fermenting roots or fruits
Drosophila ampelophila Lœw.	Trypetidæ	Any fermenting roots or fruits
Carpophilus spp.	Nitidulidæ	cassava, papaya, *ubi*, *tuge* (yams), jack fruit, eggplant
Prometopia 4-maculata Mots.	Nitidulidæ	cassava, beans, and *gabi* (taro)
Undetermined	Nitidulidæ	cassava
Colobicus parilis Pasc.	Colydiidæ	cassava
Nerius fuscus Wied.	Micropezidæ	papaya, eggplant, cassava, *gabi* (taro)
Inopeplus sp.	Cucujidæ	cassava

OBSERVATIONS

Observation was made on stored root crops in the seed laboratory of the College of Agriculture. Newly harvested and washed cassava tubers almost all rotted after a week, due to *Diplodia*. *Diplodia* was found very abundantly.

Just after washing and spraying the roots, the house and the fruit flies were noticed at once in great numbers. The wounds or bruises made in digging were frequented by the insects. After a day or two weevils and other insects were found. The insects increased day after day until the roots hardened and shrunk; many of the insects remained on this dried material. After ten days the fungus turned black most noticeably at the cracks or crevices of the bark.

Some similar cases were found on piles of eggplants and papayas. On sweet potato, rot occurred after twenty-one days. Still a longer period was observed in the case of *gabi* (taro), *ubi*, and *tuge* (yams). Numerous insects were found also.

The observations seemed to show that there must be a certain relationship between the insects and the pathogene which develops very rapidly after a visit of these pests.

INTRODUCTION OF INSECTS INTO CONFINEMENTS

Procedure.—Small glass jars about 14 centimeters in diameter and 19 centimeters high were sterilized. After heating and cooling the sand, it was placed in the jars, making a layer at the bottom 3 to 4 centimeters in thickness. Each jar was covered with a double of cheesecloth with a layer of cotton placed between to admit air but to exclude dirt or contamination. Three tubers were placed on top of the sand layer.

With a pair of flamed forceps, the insects, with the exception of the flies which were captured with a net, were picked up carefully one by one, put in a vial, brought into the laboratory and put into the prepared glass jars. At least ten insects, all collected from hosts infected with *Diplodia*, were put in each jar. For the results see "Experiments and Results."

EXAMINATION OF INSECTS UNDER MICROSCOPE

Procedure.—Insects were picked from diseased tubers with a flamed pair of forceps, put in a cyanide vial, and brought to the laboratory for observation with a 16 millimeter lens. Each insect was rolled in a drop of water on a clean slide to wash the spores from its body. The body and legs were then examined and the number of spores noted. The spores which were left in the drop of water were counted. See Table II for the results.

PLATING OF INSECTS IN POTATO-AGAR PLATES

Procedure.—Two, and sometimes four, insects were collected and plated in a potato-agar plate. They were left in the plate for an hour or two before they were removed. The plate was examined under a 16 millimeter lens and the spores were counted. In other plates a counting was made after twenty-four hours, when young mycelia had already appeared. Counting was made easy in this way, but the objection is that probably some spores did not germinate. The results are given in Table II.

Bits of mycelia from every kind of insect plated were put into six test tubes of potato-agar.

EXPERIMENTS AND RESULTS

INFECTION EXPERIMENTS

The same treatment and methods were used throughout these experiments. The insects were repeatedly tested, using the hosts where they were found most frequently and numerously. Table I shows the insects and hosts.

Each set of experiments consisted of twelve glass jars prepared, as explained above; one-half were moistened with sterilized water and the other half were left dry. Tubers or fruits placed on top of the layer of sand were slit with a flamed scalpel, except the ones already cut at one or both ends when fitted in the jars. Two jars from each of the dry and wet lots were made as controls. The insects collected from hosts infected with *Diplodia* were freed in the test jars.

Araeocerus fasciculatus De Geer.—Three tests were made with this insect, using sweet potato in the first two sets and cassava tubers in the third.

Set a.—The first test was started on November 15, 1920.

Result.—Of the dry lot, two tubers were diseased on December 15; no indication of the disease was observed in the wet lot. On December 20, five more tubers in the dry and two in the wet lot were diseased. Some moistened tubers sprouted. The diseased roots shriveled, hardened, and dried. Some insects died in all the lots. By the end of December, all the tubers in the dry jars were infected, except in one container where all the insects died. Of the twelve roots in the wet lot eight were diseased while the others sprouted. The controls remained healthy.

Set b.—Another set was started on December 10, 1920.

Result.—It was observed that on January 8, 1921, four tubers were attacked in the dry lot. No disease was observed in the wet jars. On January 20, four more in the dry lot rotted, and only three in the wet lot were infected. By the end of January all, save one tuber in the dry lot and five in the wet lot, were diseased.

Set c.—Cassava tubers were used in this test which was started on January 4, 1921.

Result.—Quick infection was observed in this test. Two tubers in the moist jars were attacked, one on January 8, and one on January 11; only two roots in the dry and four more in the wet lot rotted. On January 15, all the moist roots and a total of eight roots in the dry were diseased. In the control jars not a single tuber showed infection. The pathogene at first appeared as a cottony growth on the slits and cut ends of the tubers, turning black at the crevices and cracks of the bark of the roots after the eleventh day. The fungus developed rapidly in the moist jars.

Set d.—This test was conducted to check the only observation made in connection with citrus, i. e., the peelings of *Citrus decumana* Linn., which were infected with *Diplodia* accidentally. Many *Araeocerus fasciculatus* De Geer. were found associated with the disease.

This test was made in six glass jars, three of which were moistened and three left dry. One jar from each lot was made the control. Peelings of eight or ten fruits were put in the jars and insects collected were introduced into the confinements on January 22.

Result.—First infection was noted in the dry jars on February 4 and by February 6 the peelings in both dry jars were diseased. On February 18, both wet jars showed infection. Control cultures were healthy, although the dry peelings shriveled and turned hard.

Cylas formicarius **(?)** Fab., was used in three sets of experiments and exclusively with sweet potato roots.

Set a.—This test was started February 20, 1921.

Result.—On March 11, nineteen days after the introduction of the insects in the jars, infection was noted in the dry jars. The insects in both lots bored holes into the tubers. On March 15, all the dry jars were infected, and in the moist jars only one tuber showed infection. Tubers in the wet jars sprouted. On March 22, all tubers in the dry lot were infected and only two in the moist lot. Insects increased about the end of March and no more infection was observed in the moist jars. The insects aided the fungus in the destruction of the tubers. Upon breaking the tubers, the tissues were black. Larvae and newly emerged adults were found in the tubers.

Set b.—The second test was started on March 1.

Result.—On March 22, the disease was noticed in a dry jar and in another one on March 24, on which date not one was yet infected in the moist lot. On April 4, all the tubers in the dry jars were diseased, while not one as yet showed the disease in the moist jars. On April 18, ten tubers were badly attacked in the dry lot, while only six in the wet jars showed the disease. The control jars were not infected. Insects increased in the test jars destroying the diseased and healthy tubers.

Set c.—The last test was started April 2. Another source of *Cylas formicarius* (?) Fab., was observed while digging sweet potato roots in an old plantation for experiments. It was observed that almost all the roots were destroyed by the insect, which was found associated with the tubers under the cracked ground. Out of curiosity a test was made with the insects collected from this plantation.

Result.—It was found that throughout April and May, both the dry and wet lots, including the controls were not infected. In all the jars where the insects were the roots were entirely destroyed by the increased number of insects after five weeks. This test shows a relationship between the insects and *Diplodia* sp.

Calandra oryzae Linn., was found in many hosts, but it was tested only with cassava, sweet potato, and *gabi* (taro). Four tests were made with it.

Set a.—The test was started May 2, with this insect confined with cassava tubers.

Result.—On May 6, infection of three tubers in the moist jar and one in the dry was noticed. On May 8, all the tubers of both lots, save one in the dry jar, were infected. In one of the wet jars was observed a soft rot caused by bacteria, characterized by a yellowish, watery, soft area. Control tubers remained healthy.

Set b.—This test was started May 16, using cassava tubers in eight jars. One jar from each lot was put aside for control.

Result.—A noticeable infection started in the wet lot on May 19, and on May 20, the dry lot showed the disease. Finally, on May 25, all tubers in both lots were attacked; the controls remained healthy.

Set c.—The third experiment was started June 2, with eight glass jars of *gabi* (taro). Two jars, one dry and one wet, were left as control.

Result.—On June 20, two tubers in the wet jars and two more on June 25, were infected, on which date only two roots in the dry jars were attacked. The fungus showed slow development on this host. By the end of the month it was found that only two in the dry and five in the moistened jars had rotted. No fungus growth was found in the control jars.

Set d.—The test was arranged and started on May 25. Insects were collected from a bunch of corn ears and beans. Only six jars of sweet potato tubers were used.

Result.—The experiment was left till the end of June and no infection was noticed whatever. Many of the insects died. Some of the moistened tubers sprouted. That no infection occurred was probably because no spores of *Diplodia* were carried by the insects—being collected from hosts showing no disease.

Colobicus parilis Pasc., was scarce. However, two tests were made with it, consisting of six glass jars to each set. The host used was cassava.

Set a.—The first experiment with this insect was started June 20.

Result.—On June 24, infection was noticed in the wet lot, and the disease appeared on June 25 in one of the dry jars. All the moistened roots were attacked on June 27, on which date the fungus began to turn black. All the tubers in the dry lot rotted.

Set b.—The second test was started July 2.

Result.—After four days the wet lot showed infection and two days later the disease was noted in the dry jars. Control jars remained uninfected. On July 11, the total number of diseased tubers was six in the wet and four in the dry lot. More tests with this insect were not possible because of its disappearance.

Carpophilus spp., was found on rotting papaya fruits in the field infected with *Phytophthora* and *Diplodia*, on rotting eggplant, cassava, sweet potato, *gabi* (taro), and *ubi* (yam). Because cassava was found very susceptible to *Diplodia* it was exclusively used in the three tests with *Carpophilus* spp.

Set a.—The first test was started July 15.

Result.—The first infection was noted on July 18 in the moist lot, and on July 21 the dry lot showed the disease. On July 28, all the tubers in the moistened jars and a total number of six in the dry jars were infected. Some tubers were entirely covered with the fungus in the moist jars. In the dry lot *Rhizopus* sp. and bacteria were noted.

Set b.—The second experiment was started August 1, with six glass jars of cassava.

Result.—Rapid infection took place in both lots, starting on August 5. On August 10, all tubers were diseased in both lots. Control tubers remained healthy.

Set c.—This test was started August 6.

Result.—On August 9, the wet lot was infected, and had advanced until August 11, when the dry lot showed infection. On August 15, all tubers in both lots rotted. Controls remained uninfected. The characteristic fungus growth was observed in all three sets made.

Promotopia 4-maculata Mots., was very scarce, but an effort was made to secure a 6-glass-jar test. Cassava roots were used. Two controls were made, one from each lot. The test was started on October 25, 1920.

Result.—Both lots were infected on October 31, and on November 5, all the wet-lot tubers were attacked, and only four in the dry jars showed the disease. The test was renewed and the tubers were examined. The inside portion of the roots turned black with black fruiting bodies of the fungus on the cracks and crevices of the bark. The control tubers were partly dried but no fungus attack was observed.

Musca domestica Linn., ***and Drosophila ampelophila*** Loew., were collected with a net, so that the tests made with them cannot be relied upon. From the net the insects were put in a small vial and were brought to the laboratory. They were then freed in the prepared confinements.

The set with the house fly was started on November 10, 1920. Cassava tubers were used in twelve glass jars.

Result.—Rapid infection occurred in the wet jars, and was observed on November 15. On November 18, few insects survived in the dry jars, but infection was noticeable. Examining the jars on November 25, only three tubers in the dry lot and ten roots in the moist lot were badly diseased. The controls were not affected.

The set with the fruit fly was started on November 10, 1920. Cassava tubers in twelve glass jars were employed.

Result.—After three days the wet lot showed the disease. On November 20, bacterial infection was observed in the dry lot, three roots being attacked by *Diplodia*. In all, five in the wet jars and three in the dry lot were diseased. Many insects died in the dry jars and some in the wet. Control tubers remained undiseased.

Nerius fuscus Wied., ***Dinothrips sumatrensis*** Bag., ***Inopeplus*** sp., and the undetermined Nitidulidae.

There were too few of these insects to allow an entire experiment. It was also noted that when the chance of testing them came, it was just the time when they disappeared. Notwithstanding their scarcity, quite a number of each group was collected for examination for spores on their bodies, the result of which follows under a separate heading.

MICROSCOPIC EXAMINATION OF INSECTS FOR SPORES OF DIPLODIA ON THEIR BODIES

This study was made to find out whether the insects already tested carry spores of *Diplodia* on the outside of their bodies. Insects were collected at different dates from hosts infected with *Diplodia*, such as cassava, sweet potato, *ubi* (yam), *gabi* (taro). Upon putting an insect on the slide with a drop of water the spores were easily washed out. In many cases spores were found on the hairy legs, wings, antennae, and the abdomen.

TABLE II.—*Result of examination of insects under microscope.*

No.	Insect.	No. of insects examined.	No. of spores.	No. of insects carrying no spores.	Average number of spores for each insect.
1	*Aræocerus fasciculatus* De Geer.	34	430	—	12.64
2	*Cylas formicarius* (?) Fab.	25	244	—	9.75
3	*Calandra oryzæ* Linn.	31	306	2	9.87
4	*Colobicus parilis* Pasc.	28	235	5	8.39
5	*Carpophilus* spp.	41	242	2	5.9
6	*Promotopia 4-maculata* Mots.	30	110	8	3.66
7	*Musca domestica* Linn.	22	45	9	2.04
8	*Drosophila ampelophila* Lœw.	35	35	12	1.00
9	*Nerius fuscus* Wied.	10	9	4	0.90
10	*Dinothrips sumatrensis* Bag.	21	50	5	2.85
11	*Inopeplus* sp.	10	15	5	1.5
12	Undetermined (Nitidulidæ)	16	25	2	1.56

From Table II it appears that all the insects examined under *Araeocerus fasciculatus* De Geer., and *Cylas formicarius* (?) Fab., were carriers of spores of *Diplodia*. Some individuals of the other groups were found harboring no spores.

The first six groups in the list were carriers of many spores, while the last six carried with them only a small number easily noticeable.

Putting the average in round numbers, every *Araeocerus fasciculatus* De Geer., carried 13 spores, and therefore, appears to be the most dangerous of all the insects studied. Each of the *Carpophilus* spp., *Colobicus parilis* Pasc., *Calandra oryzae* Linn., and *Cylas formicarius* (?) Fab., carried from six to ten spores, while each of the others carried from 1 to 4 spores. This result reveals the fact that the insects associated with the stored root crops attacked by *Diplodia* were carriers of the pathogene.

PLATING EXPERIMENTS

To be more certain of the many spores found on the bodies of insects examined, some of them were plated in potato-agar. The procedure followed was briefly described under "Materials and Methods". The results of the tests made are found in Table III.

TABLE III.—*Result of plating the insects in potato-agar.*

No.	Insect.	No. of plates.	No. of insects.	No. of spores.	Average number of spores.
1	*Aræocerus fasciculatus* De Gerr.	6	18	199	11
2	*Cylas formicarius* (?) Fab.	4	10	95	9.5
3	*Calandra oryzæ* Linn.	6	13	142	10.9
4	*Colobicus parilis* Pasc.	4	8	62	7.75
5	*Carpophilus* spp.	7	20	113	5.6
6	*Promotopia 4-maculata* Mots.	3	9	46	5.1
7	*Musca domestica* Linn.	3	6	20	3.33
8	*Drosophila ampelophila* Lœw.	5	10	18	1.8
9	*Nerius fuscus* Wied.	4	8	15	1.87
10	*Dinothrips sumatrensis* Bag.	3	6	30	5.0
11	*Inopeplus* sp.	4	10	27	2.7
12	Undetermined (Nitidulidæ)	3	9	21	2.3

The spores were counted twenty-four hours from the time that the plates were made. The young mycelia were then observable with the naked eye and counting was easy. Sometimes, however, counting was done just after the removal of the insects from the plates, that is, after one to two hours. The young mycelia were found along the footprints of the insects. Together with *Diplodia* spores, some bacteria and *Rhizopus* spores were noticed.

From Table III it will be seen that a great number of spores of *Diplodia* were carried by the insects introduced into the plates. Every one in the groups of *Araeocerus fasciculatus* De Geer., and *Calandra oryzae* Linn., was found a carrier of spores, in round numbers eleven, while *Cylas formicarius* (?) Fab., and *Colobicus parilis* Pasc., each carried ten and eight spores respectively. The groups

Carpophilus spp., *Promotopia 4-maculata* Mots., *Dinothrips sumatrensis* Bag., averaged five to six spores, and the rest from two to four spores each.

These figures point out that the insects were apparently carriers of *Diplodia* spores, and confirmed the result of the microscopic examination just presented. Evidently the spores adhere to the insects' hairy bodies, and fall freely with their movements, through which means occur the infection of the root crops, tested under controlled conditions.

CULTURE OF FUNGUS FROM SPORES SHED BY INSECTS

A pure culture of *Diplodia* was obtained from stored cassava tubers. Along with this culture, for comparison, transfers were made from the young mycelia in the potato-agar plates where the insects were allowed to move around. A separate culture was made with every kind of insect tested. It was observed that the characteristic growth of the fungus was the same in all the cultures. From microscopic examination, spores appeared to be the same as those in the pure culture as to color, size, form, and septation. This shows that the young mycelia in the potato-agar plates were evidently from the spores of *Diplodia* brought by the insects.

DISCUSSION OF RESULTS

Of the twelve species of insects collected only eight were used in the infection experiments. Infection took place most readily upon the slits made at the ends of the tubers cut with a scalpel when they were being fitted in the containers.

From Table IV, it appears that all of the following insects were carriers: *Araeocerus fasciculatus* De Geer., *Cylas formicarius* (?) Fab., *Calandra oryzae* Linn., *Colobicus parilis* Pasc., and *Carpophilus* spp. These five, including the common flies, were found most frequently and abundantly on stored crops.

It will be noticed that rapid infection took place in all the tests with cassava. The length of time before infection varied with the insects and with the root crops used. Cassava was infected after 3-7 days from the time the insects were freed in the confinements, citrus was attacked after 13 days, *gabi* (taro) after 19 days, sweet potato after 19-30 days.

It will also be noted that first infection occurred always in the moist lot except in the case of sweet potato and citrus. There were more tubers diseased in the wet lots, with the exception of the sweet potato tests, where the dry jars contained more infected roots. Moistened sweet potato tubers sprouted and kept longer.

In the test with *Calandra oryzae* Linn., and *Cylas formicarius* (?) Fab., when they were collected from the hosts free from *Diplodia*, no infection was observed. This freedom from infection indicates that spores of *Diplodia* were not carried by them.

Out of 48 sweet potato roots confined with *Araeocerus fasciculatus* De Geer., 35 were infected, and out of 24 cassava tubers 20 were diseased. The citrus peelings were also attacked.

With *Cylas formicarius* (?) Fab., collected from diseased hosts, out of 48 sweet potatoes, 30 rotted.

Of the 42 cassava tubers tested with *Calandra oryzae* Linn., 41 were infected, and 7 *gabi* (taro) tubers out of 18 tested were diseased.

The total number of cassava tubers infected through the agency of *Colobicus parilis* Pasc., was 22 out of 24 tested; probably all would have been diseased had the test been prolonged.

With *Carpophilus* spp., 42 out of 48 cassava tubers rotted.

There were 10 infected roots of cassava brought about by *Promotopia 4-maculata* Mots., out of 12 in the lots.

With the flies, the house fly caused 13 tested cassava tubers out of 24 to rot and the fruit flies infected 8 out of 24.

With all these tests no disease was observed in all the control tubers in the dry or wet lots, while in the case of sweet potato, moistened tubers sprouted and the dry ones shrank and were soft and tough to the touch.

In the examination of the bodies of the insects a great number of spores were observed on the hairy legs, antennae, and wings. From Table II, it appears that not a single insect under the groups *Araeocerus fasciculatus* De Geer., and *Cylas formicarius* (?) Fab., was observed not to carry spores. These two insects and *Calandra oryzae* Linn., *Colibicus parilis* Pasc., *Carpophilus* spp. and *Promotopia 4-maculata* Mots., were carriers of many spores, and except *Promotopia 4-maculata* Mots., were the most efficient in causing infection. Some of the other groups were observed not to carry spores. In spite of this, although the number of spores found was small, they caused infection in the tests made with them.

The spores clinging on the insects' bodies fall off easily. Since the flies were captured with a net, few spores were observed on them under the microscope.

By plating the insects, colonies of *Diplodia* sp., bacteria and other fungi were found along the footprints of the insects. From Table III, the recorded number of young mycelia is sufficient to supplement the examination of insects which aimed to prove why the insects were infective when tested with sound roots. From the plating test it was shown how easily the spores fall with the movement of the insects and how easily the spores germinate after twenty-four hours. This explains the rapid rotting of the stored root crops, especially cassava. Because bacterial colonies were observed in the agar plates, the bacterial infection in the cases of the fruit fly, the rice weevil, *Calandra oryzae* Linn., and *Carpophilus* spp., is to be expected although the infection may be of a secondary nature. It has, nevertheless, manifested itself to be a wet rot carried by the insects.

SUMMARY AND CONCLUSIONS

1. *Diplodia* sp. causes a dry-rot on stored crops. It may be disseminated in various ways like other plant diseases. Barrett and Burrill found that it could be blown by wind 350 yards from an infected ear of corn.

2. Insects were found to disseminate the *Diplodia* spores.

3. Insects found carrying spores belong to the families: Anthribidae, Calandridae, Cucujidae, Colydiidae, Curculionidae, Muscidae, Micropezidae, Nitidulidae, Phloeothripidae, and Trypetidae (Table I).

4. Of the twelve kinds of insects collected, *Araeocerus fasciculatus* De Geer., *Cylas formicarius* (?) Fab., *Calandra oryzae* Linn., *Colobicus parilis* Pasc., *Carpophilus* spp., and the two common flies were the most abundant groups on stored

roots and fruits. These, including *Promotopia 4-maculata* Mots., were all found capable of producing infection upon sweet potato, *gabi* (taro), cassava and citrus.

5. All the insects examined were carriers of spores which easily fall with their movements.

6. Not only *Diplodia* spores were carried by the insects but also bacteria and spores of other fungi.

7. Provided that the insects come across *Diplodia* infection they become carriers of the spores, as shown by *Calandra oryzae* Linn., and *Cylas formicarius* (?) Fab., where they caused no infection.

8. From the literature reviewed, insects were found carriers of spores of plant pathogene through their digestive systems and on the outside of their bodies. *Diplodia* was found carried by insects outside the bodies, especially on the hairy legs, antennae, etc.

9. Moisture made the sweet potato tubers resistant to the attack of *Diplodia.*

10. In the case of cassava, disease developed after three days with the insects.

11. Infection was first observed upon the cuts and bruises of the roots.

12. The insects were found to feed upon the roots, breed in them, and disseminate the pathogene.

RECOMMENDATIONS

1. The most effective measures to exclude these insects is by marketing agricultural products after harvest, or by keeping them in bins and barrels disinfected with formaldehyde (3 pints to 50 gallons of water), so that the insects cannot gain access.

2. *Calandra oryzae* Linn., prefers dark places; sunlight will then prevent its presence according to Kellogg (36) who further says that fumigation with carbon bisulfide will kill the pest in air-tight boxes. Fumigation most likely will be efficient against all the insects found on stored crops.

3. Injured tubers must be kept separate in storing, as the bruises or wounds are the spots frequented by the insects carrying the disease.

4. Diseased tubers should be thrown away, burned or buried in the ground as soon as detected, so that the insects may have a smaller chance of contact.

5. Sweet potatoes should be stored in a moist place; *gabi* (taro), cassava and citrus in well ventilated places.

6. Properly screened storage places will exclude all the insects that carry the spores.

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TABLE IV.—*Summarized results of the infection experiments.*

Insect.	Set.	Materials tested.	No. of tubers tested.	Date begun.	First infection.		Final observation.			Remarks.
					Date.	Lot.	Date.	No. of diseased tubers. Lots. Dry.	No. of diseased tubers. Lots. Wet.	
Aræcocerus fasciculatus De Geer.	a	sweet potato	24	November 15	December 15	Dry	December 31	9	8	Insects died in 1 dry jar
	b	sweet potato	24	December 10	January 8	Dry	January 30	11	7	
	c	cassava	24	January 4	January 8	Wet	January 15	8	12	
	d	citrus	Peelings.	January 22	February 4	Dry	February 18	Both infected		
Cylas formicarius (?) Fab.	a	sweet potato	24	February 20	March 11	Dry	March 22	12	2	Some tubers sprouted
	b	sweet potato	24	March 1	March 22	Dry	April 18	10	6	Insects destroyed some tubers
	c	sweet potato	24	April 2	——		May 30	No infection		Insects from field
Calandra oryzæ Linn	a	cassava	24	May 2	May 6	Both.	May 8	11	12	Soft rot in wet lot
	b	cassava	18	May 16	May 19	Wet	May 25	9	9	
	c	*gabi* (taro)	18	June 2	June 20	Wet	June 30	2	5	
	d	sweet potato	12	May 25	——		June 30	No infection		Insects from corn and beans
Colobicus parilis Pasc.	a	cassava	12	June 20	June 24	Wet	June 30	6	6	
	b	cassava	12	July 2	July 6	Wet	July 11	4	6	
Carpophilus spp.	a	cassava	24	July 16	July 18	Wet	July 30	6	12	Bacteria and other fungi noted
	b	cassava	12	August 1	August 5	Both.	August 10	6	6	
	c	cassava	12	August 6	August 9	Wet	August 15	6	6	
Promotopia 4-maculata			12	Oct. 25, 1920	Oct. 31, 1920	Both.				

THE MOSAIC SITUATION[1]

By Frank P. McWhorter
Of the Department of Plant Pathology

Cane mosaic is so serious in the Philippine Islands that the newspapers run headline articles on the subject, and perhaps for this reason the word "Mosaic" is thought to refer particularly to a disease of sugar cane. However, this is not the only crop subject to the disease for it seriously affects maize, tobacco, tomatoes, and many other crops. Indeed, plants belonging to as many as twenty different families are subject to it. This paper is presented as a more or less popular review of recent important work on the subject.

Mosaic diseases have certain symptoms in common, no matter what the host. These symptoms are:

1. Mottled leaves: the spots look as though they had been soaked in water. This condition is best seen in reflected light.

2. General dwarfing of the plant.

3. Curling of the edges of the leaves in tender-leaved plants.

These three symptoms may be present at the same time. Unless No. 1 is present the disease cannot be conclusively diagnosed as mosaic.

The disease should not be confused with albescence, a term used in describing yellow and green spotted leaves such as those produced by the San Francisco plant *Codiaeum variegatum*. Such mottling is not generally considered a disease but a natural inherited character.[2] Another condition of whitened leaves with which mosaic should not be confused is chlorosis which condition is brought about by the deficiency of some element in the soil.

For mosaic in general we know a few unquestioned facts that are of value in understanding the disease. The more important of these are:

1. That if the juice of a mosaic diseased plant is inoculated into a healthy plant of the same species, the latter plant may become diseased. In other words, something capable of producing the disease is present in juice extracted from the plant.

2. That a substance present in the juice, and having the power of producing the disease, is of such extremely small size that it will pass through very fine filters, such a substance being known as a filterable virus. But the fact that there is a filterable virus present by no means proves that there is not a definite causal organism. From what does the virus come? Some filterable viruses are self-perpetuating.

3. That insects, chiefly aphids, are able to transmit the disease from one plant to another.

4. That many mosaics, notably bean mosaics, are inheritable—that is, carried over in the seed.

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[1] Experiment Station Contribution No. 121.

[2] It may yet be shown that albescence results from a symbiotic mixture of host and parasite that is transmitted from seed to seed; mosaic can be inherited.

5. That cuttings from diseased plants are almost certain to reproduce the disease. This fact, of course, is important in accounting for the distribution of cane mosaic throughout the Philippines.

These are the generally accepted facts; what causes mosaic is the important and much discussed question.

Kunkel and Matz have described "foreign bodies" in the pith cells of mosaic-diseased maize and cane respectively. These bodies are hard to see and require very careful work for their demonstration. It is by no means certain that these bodies are living organisms. Such bodies, in the case of maize, are not present in healthy maize, but the writer has demonstrated in healthy cane bodies similar to those described by Matz. As yet there is little proof that these cause the disease; they are possibly the result of the disease.

Since mosaic may be regarded as a disease of the mal-nutrition type one would expect the internal seat of the trouble to lie in the phloem, the tissue that is most important in distributing food throughout the plant. Ray Nelson (1), whose recent paper I wish to review in detail, decided for two reasons that the real cause of the trouble must lie in the phloem. Briefly these reasons were: (a) In potato leaf-roll, a disease closely allied with mosaic, the phloem is partially destroyed. (b) That aphids, which are the chief agents for spreading the disease, extract their food largely from the phloem. His exact statement is. "The feeding habits of these insects offer valuable evidence as to the probable nature and location of the causal organisms. Those species known to transmit these diseases take their food material from the phloem tissues of the host plants, and after feeding for some time upon the veins and parts of the plants close to the phloem they are capable of transmitting the disease to healthy plants. Other species which do not attack the food-conducting tissues have not been shown consistently to be carriers of the infectious agents". He does not give his proof of the statement, but in the case of sugar cane, Brandes (2) backs him up most excellently. He (Brandes) was able to section aphids feeding on cane leaves and in his paper presents micro-photographs showing the beaks of the insects in place in the phloem region of sugar cane leaves. Seeking for the causal organism in the phloem region of mosaic diseased leaves Nelson got startling results. He demonstrated the presence of protozoa which apparently belong to the order Flagellata. These organisms are very different from the amoeba protozoan described by the writer as the probable cause of Fiji disease.[3] Nelson investigated several mosaic hosts and found protozoa of two types as follows:

Type 1. The type in bean and clover mosaic. This he calls the Leptomonas type. The protozoan there found is a tiny one-celled animal, motile by means of two flagella. He demonstrated the protozoa by means of stained sections and by direct examination of fresh, unstained sections. With a magnification of approximately 400 times they could be seen rapidly moving in the phloem cells. He considers them to be of the Leptomonas type because they are somewhat similar to protozoa that have been described by Lafont and others in the latex (milk tubes) of the Euphorbiaceae. In regard to their causing mosaic, he gives two statements which are strong evidence but not conclusive proof. They are, (a) that protozoa are not present in healthy bean and clover plants, and (b) that

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[3] McWhorter, Frank P. The nature of the organism found in the Fiji galls of sugar cane. **The Philippine Agriculturist 11**: 103-111. *Pls. 1-2.*

the same kind of protozoa are found in diseased plants of both bean and clover which is very suggestive since it has been proven that bean can be infected with clover mosaic and clover with bean mosaic. This second statement is further emphasized by the fact that tomato, in which he found a different kind of protozoan, cannot be infected with the mosaic of bean or clover.

Type 2. The tomato mosaic and potato (leaf-roll) type. In the phloem of mosaic diseased tomatoes, and of potatoes diseased with leaf roll, (a closely related disease), he found protozoa resembling trypanosomes. Trypanosomes are one-celled animals that move by means of an undulating flap-like membrane; in man and other animals they cause many serious diseases, such as sleeping sickness, surra, douraine, etc. These trypanosome-like protozoa were not present in healthy plants of either species. He points out that certain trypanosomes, notably *Trypanosoma brucei*, which causes the horse disease known as "nagana" throw off from their bodies tiny particles capable of producing the disease, hence the trypanosomes may prove to be the source of the filterable viruses known to be present.

From the work of Nelson we have the first really tangible cause of mosaic but much investigation has yet to be done before actual proof can be given that any mosaic disease is due to a protozoan. His paper gives convincing proof that protozoa are present in certain mosaic diseased plants.

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NOTE ON POISONING OF FOWLS BY *PASSIFLORA FOETIDA*[1]

By D. A. Herbert
Of the Department of Plant Physiology

Passiflora foetida is a tropical American vine naturalized in the Philippines and fairly common around Los Baños. In parts of the Islands it is used as a cover crop in coconut plantations. It smothers the weeds and when the coconuts have attained a certain height cattle are turned in and the vine eaten and trampled down.

Specimens of this plant in the flowering stage were submitted for identification by Dr. Miguel Manresa of the College of Veterinary Science in the first week of June. A number of fowls had died from eating the plants on Faculty Hill and five sick ones had been forwarded to the College for treatment. Examination of the material submitted showed that it had a high prussic acid content and to this the poisoning was undoubtedly due. Pammel in his *Manual of poisonous plants* records the species as cyanophoric. This note is published as a piece of definite evidence of poisoning by *Passiflora foetida* and goes to show that cyanophoric plants, two lists of which have been published by this Department (1) (2), must be looked on with extreme suspicion. In this case we have a plant of recognized fodder value suddenly developing toxic properties. It is all the more dangerous because it is not liable to be suspected on account of its usual usefulness.

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[1] Experiment Station contribution No. 122.

COLLEGE AND ALUMNI NOTES

Dr. B. M. Gonzalez of the Department of Animal Husbandry has returned to the college after an absence of two years in America and Europe as a pensionado. He graduated from Johns Hopkins University in Febraury 1923 with the degree of Doctor of Science (in Hygiene) the subject of his thesis being "The chromosomal localization of five factors determining duration of life in *Drosophila melanogaster*." The degree was conferred in absentia, Doctor Gonzalez having left America for the Philippines via Europe on December 4, 1922. He stayed approximately two months in Germany taking informal lectures at the University of Halle-Wittenberg. He visited various Universities and other educational institutions in Germany, Belgium, France, England, Holland, and Spain, and the homes of the Jersey and Guernsey cattle, the Percheron horse, and the Berkshire pig. Embarking at Marseilles, he returned to the Islands on a French liner, and arrived in Manila on April 23, 1923.

The directory of the college of Agriculture Alumni Association has been published in Volume XI, Number I of this Journal. The members of the association are requested to help the Secretary to keep this directory up to date by reporting to him all changes of address.

Mr. Elayda, '15, President of the College of Agriculture Alumni Asociation has been advised by telegram from Mr. Marcelino Constantino, '16, of the early death of our friend and co-alumnus Filoteo Rodis, '22, of Indang, Cavite. He died on June 10, 1923, and the funeral services were held in his home town the following day. The association, through its Secretary, has sent a telegram of condolence to the parents of Mr. Rodis expressing its heartfelt regret for this untimely demise of one of its members.

On the night of May 19, 1923, Dr. and Mrs. B. M. Gonzalez were surprised at their home by a party headed by the staff of the Department of Animal Husbandry. The bunch moved to the Roxas Residence where dancing was indulged in till the wee hours of the morning. The party was graced by some of the members of the Makiling Ladies Club, and a number of young ladies from Los Baños and Lipa. This party was given on the occasion of the recent arrival of the family from abroad.

Dr. R. B. Espino in charge of the work on abaca and coconut at the College of Agriculture spent the summer vacation in Davao, making a brief survey of the abaca and coconut industries of the province. He is very much impressed by the conditions of abaca and some of the coconut haciendas there, and speaks very highly of the courtesy and hospitality of the Davao people in general and of the hacenderos in particular. He brought back to the College specimens of abaca and of coconuts. Some are to be studied and others are to be planted.

Dr. Espino believes that in five years the province of Davao will have about one million coconut trees in full bearing stage. He also reports that the abaca stripping machines are fast relieving men from the most difficult task of extraction of abaca fiber, but believes that the machines require further improvement with respect to cleanliness of the fiber produced and further elimination of employment of men.

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Mr. Santiago Festin, '18, was a visitor in the College a few weeks ago. He was a deputy governor of Davao from 1917 to 1921. From 1921 to June 19, 1923, he worked as Technical Agricultural Assistant and Industrial Supervisor of the Bureau of Agriculture for all the settlement farm schools in that province. He resigned from this position to become principal teacher in the agricultural school in Odioñgan, Romblon, his home town.

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Dr. Marcos A. Tubangui of the College of Veterinary Science was married to Miss Pacita del Rosario of Manila in June 2, 1923. They spent their honeymoon partly in the Sibul Springs, partly in Los Baños, and partly in Pampanga, the home province of Dr. Tubangui. Dr. Tubangui, in addition to his regular duties in the Veterinary College will now teach zoology to the agricultural students. Mrs. Tubangui, is a younger sister of Mrs. Sixto A. Francisco, a resident of Faculty Hill.

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Dr. L. B. Uichanco, '15, of the Department of Entomology, was recently elected fellow of the American Association for Advancement of Science. He has been a member of that organization since 1921.

———

Mr. Amando Laparan, '14, is now stationed at Calamba, Laguna, as extension agent of the Bureau of Agriculture. His former headquarters were at Sta. Cruz, Laguna.

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Mr. Severino S. Aquino, '22, resigned his position in the Entomology Department at the College of Agriculture in order to engage in farming at San Carlos, Pangasinan, his home town.

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Messrs. Vito C. Rada and Felix S. Manipol, who had been students in this College in its earlier days, recently returned in order to continue their agricultural courses.

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Mr. Gaudencio M. Reyes, '20, who is a scientific assistant in the Mycology Division of the Bureau of Science, Manila, is spending his leave of absence at this College where he is taking post-graduate work in Plant Pathology.

Dr. Valente E. Villegas, '13, of the Department of Animal Husbandry, will soon occupy his new house which is being erected on his own lot adjoining the College grounds.

One of the latest additions to the "June brides" on the Faculty Hill was brought about by the recent arrival of Dr. and Mrs. F. M. Fronda from their honeymoon trip spent in and around Manila. They were married in Bay, Laguna, on May 28, 1923. Mrs. Fronda was formerly Miss Elpidia P. Eusebio of Los Baños, Laguna. Dr. Fronda is a member of the class of 1919, and is at present an instructor in the College, and the Secretary of the College of Agriculture Alumni Association.

Mr. Alejo T. Taleon, '21, a graduate assistant in the Department of Animal Husbandry, spent a three-week vacation in Tigbawan, Iloilo, his home town. He recently returned to duty in the College.

Mr. Feliciano Reveche, '22, has been appointed graduate assistant in entomology. His work will be to help in the investigations on sugar cane insects which are being conducted by the Department of Entomology.

Gregorio M. Francisco, '17, is now managing his own farm and an additional 2255 hectare-farm for another landowner. He resides in Sta. Rosa, Nueva Ecija, and in his last letter, he says:

"I love the farm so much that I am devoting all my life to it. Tell our brother agriculturists that there are unbounded opportunities for every live farmer and especially for those who are not afraid to get their feet and hands soiled." May we ask him this question: "What opportunities are there for our *marca señoritas?*"

An Agronomy Seminar is held in the Agronomy building every Friday afternoon from four to five under the management of Dr. R. B. Espino. The first meeting was held on June 22, 1923. Prof. M. B. Raymundo talked on "The growing of rice in California" and Dr. N. B. Mendiola gave an interesting report on "Chico marcottage and some of its business aspects". Excellent refreshments were served by Mr. P. A. David, a member of the Agronomy Staff. The second meeting will be held in the same place and at the same hour on Friday, June 29. Dr. Espino will talk on "Some facts in abaca industry of Davao not hitherto reported". Mr. David will report on "Comparative merits of three varieties of coffee as grown under Los Baños conditions". Refreshments will be served. Professor Raymundo, Mr. Punzalan and Mr. L. Gonzalez will act as hosts.

On June 18, 1923, the Los Baños Chapter of the patriotic and academic brotherhood Rizal Center held its annual election with the following results:

Brother R. B. Espino.....Supreme Noble.
Brother M. Manresa.....Second Noble
Brother P. Rodrigo.....Third Noble

Brother A. Gordon.....Fourth Noble
Brother J. Juliano.....Fifth Noble
Brother L. Sanchez.....Chaplain
Brother G. Antenor-Cruz.....Lecturer
Brother D. Divinagracia.....Orator
Brother T. F. Novero.....Steward
Brother Z. Montemayor.....Brother Guard.

With the aim of keeping alive the spirit of brotherhood, the "live-wire" Fraters of the Los Baños Chapter of Rizal Center have held a series of "blow-outs" during the last few weeks. The last one was given in the home of Dr. and Mrs. Espino by brethren Manresa, Cendaña, Tan and Espino.

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